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ANNUAL FRUIT PRODUCTION OF PRICKLYPEAR (*OPUNTIA ENGELMANNII*) AND MESQUITE (*PROSOPIS GLANDULOSA*) IN SOUTHERN TEXAS

Lamar A. Windberg

U. S. Department of Agriculture, Animal Health and Plant Inspection Service
Denver Wildlife Research Center, Utah State University
Logan, Utah 84322-5295

Abstract.—Fruit production by Texas pricklypear (*Opuntia engelmannii*) and mesquite (*Prosopis glandulosa*) was estimated from 1979 to 1988 in Webb County, Texas. The annual percentages of fruiting pricklypear and mesquite plants were variable and positively correlated. There were no detectable relationships between the percent of plants bearing fruit, mean numbers of fruit per plant, and the Fruit Productivity Index and rainfall during five phenological periods for either pricklypear or mesquite. However, less fruit production during two to three years of relatively high rainfall in the pre-flower and flowering period (January-April) suggests that both species may divert physiologic resources from reproduction to vegetative growth under conditions of excess soil moisture.

Texas pricklypear (*Opuntia engelmannii*) and mesquite (*Prosopis glandulosa*) are predominant shrubs in the Rio Grande Plains of southern Texas (Archer et al. 1988). Fruit of both species is utilized heavily by a wide variety of wildlife in the region (Everitt & Drawe 1993). The value of their fruit as a food source for wildlife may be most important during periods of low rainfall. Droughts occur frequently in southern Texas as the climate is characterized by extreme variability in rainfall (Norwine 1978).

Desert shrubs are adapted to produce greater vegetative growth in response to increased precipitation. However, the plants must balance their resource allocation between vegetative gains and reproductive output for survival (Bowers 1996). The mechanism that controls plant response in terms of vegetative growth versus flower bud production has not been identified (Inglese et al. 1995). In pricklypear and mesquite, reproduction is partially related to vegetative growth in the prior year. Flowers develop from the areolar meristems in pricklypear, which can produce either a flower or a cladode (Bowers 1996). Mesquite fruit is set from flower buds formed during the previous growing season (Peinetti et al. 1991).

The influence of rainfall on productivity of pricklypear and mesquite has received limited attention. Based on a four year study of *O.*

engelmannii in the Sonoran desert, Bowers (1996) suggested that the initial number of flower buds was controlled by intrinsic factors (plant size) and that December-February rainfall affects the proportion of flowers which develop fruit. The objectives of this study were to estimate annual fruit production of pricklypear and mesquite for 10 years (1979-1988) in southern Texas and to analyze variability of productivity in relation to rainfall patterns.

METHODS

Annual production of pricklypear and mesquite was sampled before fruit ripened on a study area of 700 km^2 located 10-40 km northeast of Laredo, Webb County, Texas, during 12 June-16 July, 1979-1988. Topography, soils, vegetation, climate, and land use for the study area were described by Windberg et al. (1985).

Thirty-two permanently-marked sample plots (7 by 45 m) were systematically spaced ≥ 3 km apart. The proportion of fruiting plants was estimated annually by recording presence or absence of set fruits on all reproductive plants within plots. Reproductive plants were arbitrarily defined as those ≥ 2 m in height for mesquite and with ≥ 20 cladodes for pricklypear. Fruit production per plant was estimated by counting the number of mesquite pods or pricklypear tunas on one reproductive plant of each species nearest the base-corner of each plot. If reproductive plants were absent inside plots, fruits were counted on the nearest reproductive plant ≤ 50 m outside the plot. Mean numbers of fruit per unit of plant were derived by dividing the (1) number of pods/m of plant height for mesquite and (2) number of tunas/20-cladodes for pricklypear. An annual Fruit Productivity Index (FPI) was calculated by multiplying the proportion of reproductive plants by the mean number of fruits per unit of plant. Monthly rainfall was recorded at two stations near Laredo, Texas (NOAA 1978-1988; IBWC 1978-1988).

Annual estimates of the percentage of plants bearing fruit were analyzed by chi-square tests of 2-way contingency tables. Mean numbers of fruit per unit of plant were analyzed with 1-factor analysis of variance. Mean percentages of plants with fruit were compared between selected years with unpaired t-tests. Relationships between fruit production of the two species, and between fruit-production variables and rainfall, were analyzed by linear correlation.

Table 1. Annual estimates of fruit production for pricklypear and mesquite in southern Texas, 1979-1988.

	Pricklypear				Mesquite			
	Plants with Fruit		No. Fruit per Plant*		Plants with Fruit		No. Fruit per Plant**	
Year	*n*	%	*n*	$\overline{X}$ *(SE)*	*n*	%	*n*	$\overline{X}$ *(SE)*
1979	224	63	30	5.4 (1.2)	99	0	2	347.5 (122.0)
1980	201	79	32	9.6 (2.3)	122	31	29	10.3 (5.4)
1981	331	50	29	3.0 (0.5)	132	11	9	68.0 (19.3)
1982	248	82	31	12.4 (3.7)	124	73	31	29.8 (7.4)
1983	231	87	31	12.6 (3.7)	120	78	32	24.2 (8.4)
1984	236	86	31	14.4 (3.1)	118	95	32	80.6 (26.4)
1985	253	92	32	10.7 (2.3)	112	27	32	6.2 (2.2)
1986	234	89	32	7.9 (2.0)	115	80	32	45.4 (10.9)
1987	252	89	32	11.3 (3.2)	125	49	32	20.2 (5.5)
1988	266	80	32	14.5 (5.2)	140	47	32	18.4 (6.3)

* Number of tunas per 20 cladodes.

** Number of pods per 1 m of plant height.

RESULTS

Annual fruit production of pricklypear and mesquite on the study area varied during 1979-1988 (Table 1; Fig. 1). The percent of pricklypear plants bearing fruit was lowest in 1979 (63%) and 1981 (50%). The percent of mesquite plants with fruit was more variable than pricklypear (CV = 65% and 17%, respectively), and was also numerically lowest in 1979 (0) and 1981 (11%). The annual percentages of fruiting pricklypear and mesquite plants were positively correlated ($r = 0.67$, $t = 2.6$, 8 *df*, $P = 0.04$).

Mean sizes of reproductive plants sampled during the study were 2.7 m ($SE = 0.3$) for mesquite and 59.7 cladodes ($SE = 2.7$) for pricklypear. There was greater annual variability in mean numbers of fruit per unit of plant for mesquite (CV = 87%) than pricklypear (CV = 37%), and no correlation ($r = -0.03$) between species (Table 1). The annual percentages of fruiting plants and mean numbers of fruit were positively correlated ($r = 0.75$, $t = 3.2$, 8 *df*, $P = 0.01$) for pricklypear, but not mesquite ($r = 0.47$, $t = 1.5$, 8 *df*, $P = 0.18$).

There was no correlation ($r = 0.43$, $t = 1.3$, 8 *df*, $P = 0.21$) between the annual FPIs for pricklypear and mesquite. There was no relationship between the FPIs in consecutive pairs of years for either

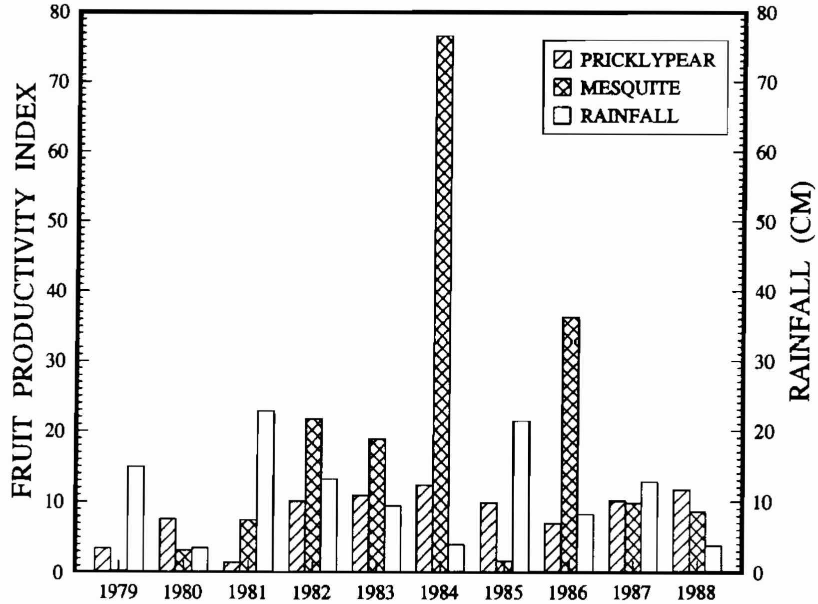

Figure 1. Annual Fruit Productivity Indices for pricklypear and mesquite and total rainfall during January-April in Webb County, Texas, 1979-1988.

pricklypear (r = 0.22) or mesquite (r = - 0.20), which indicated that annual productivity was not influenced by fruit production in the preceding year.

Pricklypear and mesquite bloomed and set fruit chiefly during April. There were no detectable relationships ($t \leq 2.2$, 8 df, $P \geq 0.07$) between rainfall during five phenological periods and the three fruit productivity variables for pricklypear and mesquite (Table 2). The phenological periods analyzed were: (1) the prior growing season (Apr.-Oct.); (2) dormant season (Nov.-Mar.); (3) cool season (Dec.-Feb.); (4) pre-flower and flowering (Jan.-Apr.); and (5) flowering and fruit-set (Apr.-May). The strongest trend was a negative relationship between rainfall during January-April and fruit production (Table 2; Fig. 1). However, that relationship was attributable primarily to lower ($t \geq 2.9$, 8 df, $P \leq 0.02$) percentages of pricklypear and mesquite bearing fruit in two years of relatively high rainfall (1979 and 1981). The percentage of mesquite bearing fruit was also low (27%) in another high

Table 2. Coefficients (r) for relationships between rainfall and fruit production variables of pricklypear and mesquite in Webb County, Texas, 1979-1988.

Rainfall Period (Months)	Pricklypear FPI*	Pricklypear % Plants with Fruit	Pricklypear $\overline{X}$ No. Fruit per Plant	Mesquite FPI*	Mesquite % Plants with Fruit	Mesquite $\overline{X}$ No. Fruit per Plant
Prior growing season (April-October)	- 0.01	0.14	0.02	0.07	0.31	- 0.02
Dormant season (November-March)	- 0.28	- 0.04	- 0.40	- 0.25	- 0.15	- 0.19
Cool season (December-February)	0.21	0.37	0.10	- 0.22	0.08	- 0.29
Pre-flower and flowering (January-April)	- 0.55	- 0.41	- 0.61	- 0.45	- 0.56	0.18
Flowering and fruit-set (April-May)	- 0.52	- 0.45	- 0.57	- 0.27	- 0.43	- 0.01

* Fruit Productivity Index (see METHODS).

rainfall year (1985), but productivity of pricklypear was normal (Fig. 1). During the 10-year study, the percentage of mesquite plants bearing fruit was markedly less during three years when rainfall exceeded 15 cm during the pre-flower and flowering period.

DISCUSSION

Mature cacti tend to flower every year (Nobel 1988). A high proportion of pricklypear with set fruit was observed each year during this study in southern Texas. In the two years when productivity of pricklypear was markedly less than normal, rainfall was high during the pre-flower and flowering period. This relationship suggested that pricklypear may have responded to the greater precipitation with increased vegetative growth and reduced reproduction. However, the trend was not consistent because productivity was normal during a third year of equally high rainfall (1985). No other relationships were found between annual productivity of pricklypear and rainfall, including precipitation during December-February where Bowers (1996) reported a direct relationship between productivity and rainfall in the Sonoran desert. The more arid climate of that region, compared with the Rio Grande Plains, may have predisposed plants there to respond positively to the effect of cool-season rainfall.

In a review of mesquite phenology, Mooney et al. (1977) reported that the seasonal timing of blooming is relatively constant annually but <3% of flowers initiated fruit development and only one-half to one-third of those subsequently produced fruit. Similarly, Peinetti et al. (1991) reported <1% of mesquite flowers developed fruit. Phenological observations by Mooney et al. (1977) indicated that flowering and fruiting in *P. glandulosa* and *P. velutina* varied annually. They stated that low soil moisture resulted in heavy flowering, and that high soil moisture suppressed flowering. Nilsen et al. (1991) also reported that water limitation resulted in greater reproduction by *P. glandulosa*, and inferred that reproductive allocation was induced and vegetative growth suppressed during dry years. Lower productivity of mesquite was observed in three years of relatively high rainfall in the pre-flower and flowering period during this study. This notable trend supports the hypothesis that a threshold of soil moisture at time of flowering triggers a plant response of increased vegetative growth and reduced reproduction.

Mooney et al. (1977) suggested that rainfall during the flowering period also resulted in low fruit production by mesquite, but no relationship between annual productivity of either mesquite or pricklypear and rainfall was found during the flowering and fruit-set period in this study. Mooney at al. (1977) mentioned that unusually cold weather in winter and spring adversely affects fruit production in mesquite. Temperatures were generally normal at Laredo in March during 1979-1988 (NOAA 1978-1988), except for a sub-freezing low (- 3°C) on 2 March 1980 when fruit production was normal for pricklypear but relatively low for mesquite.

The xerophytic adaptations of desert shrubs probably tend to negate the effects of variable rainfall on their productivity. Water storage in cladodes of pricklypear assures a relatively constant supply for physiologic requirements. Nobel (1988) estimated that the water requirement for reproduction represented only 6% of the stem water at time of flowering in *Ferocactus acanthodes* (a barrel cactus), which generally occurs during the seasonal drought in spring. The extremely deep root system of mesquite (Solbrig & Cantino 1975) is the mechanism which provides adequate water for survival and reproduction. Yet the positive correlation between the proportion of pricklypear and mesquite plants bearing fruit annually in southern Texas implicates the influence of extrinsic factors. Although this study did not assess any other potential factors, such as differential pollination and various diseases, there was evidence that heavy rainfall before and during flowering depressed fruit production of pricklypear and mesquite.

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